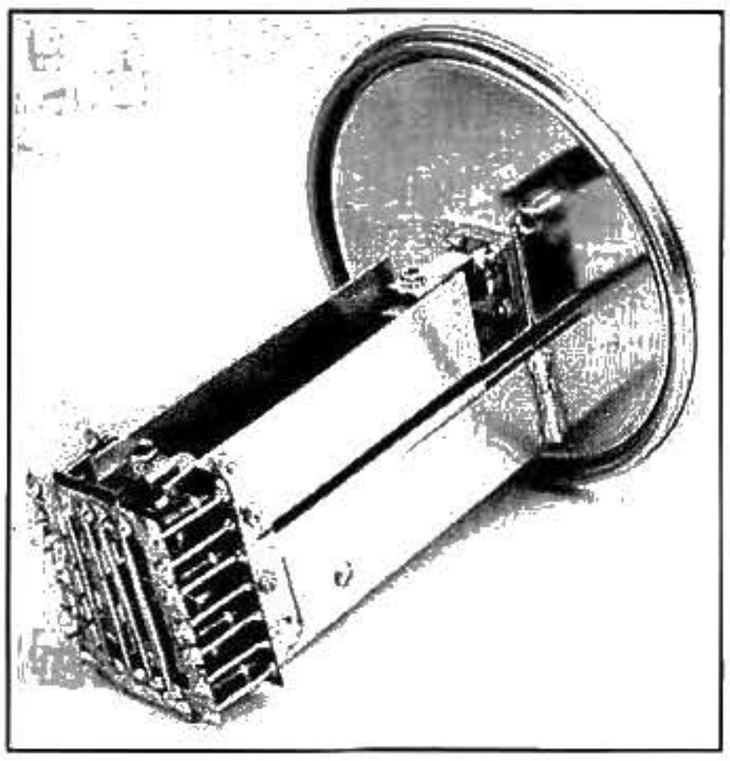
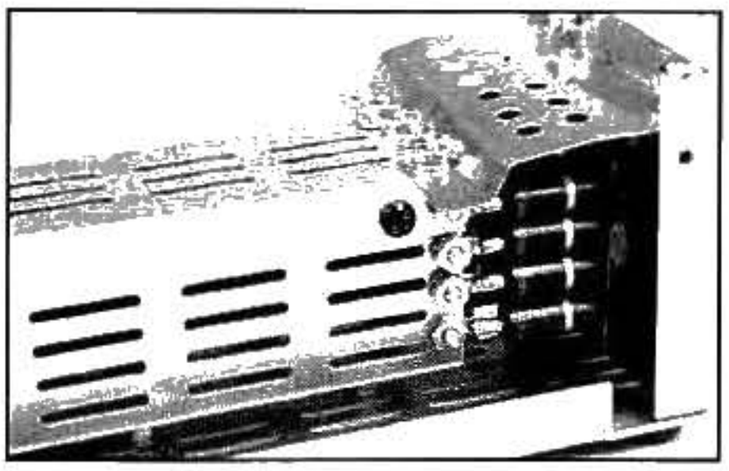
By Erik Basilier, WU7O

Build a Power Attenuator





Add a low-power *output* port to your dummy load for signal sampling, QRP or transverter operation.

New owners of spectrum analyzers soon face the problem of how to obtain a low-level sample of transmitter output for spectral purity checks, etc. Most couplers and samplers provide a flat response only over a limited frequency range. For convenient, accurate sampling, a power attenuator is hard to beat!

When observing harmonics, it is essential that the attenuator works well to frequencies several times the fundamental. Also, transmitter harmonics may increase drastically as output power approaches its maximum; it is essential to test at your normal output power.

I decided to build a power attenuator based on inexpensive dummy loads designed for amateur use. The challenge was to obtain great attenuation in spite of reactive leakage, while maintaining a wide frequency range and low input and output SWR.

My first attenuator was a **T** network constructed from a pair of Heath Cantennas (no longer available new), with the second shielded resistor mounted alongside the first in a single can. The resistor ends were joined, and grounded via eight parallel-connected 20-Ω, 2-W carbon resistors. With a brass shield soldered to the lid between the two resistors, the unit was useful to about 250 MHz. Next, I applied the approach to two dummy loads currently on the market: The MFJ-250 is an oil-cooled model similar to the Cantenna, and the MFJ-264 is a compact dry model that can handle high power for brief periods only. I describe both in this article.

Figure 1 shows the schematic for both units. You'll need two MFJ-250s to make one attenuator. The dry model uses a single MFJ-264. Both units work to about 450 MHz (see Table 1). Your results may differ.

Construction

Fabricate the brass parts from 4-inch-wide brass sheets, available at hobby stores. The figures show the sheet thickness for each part. The sheets are too thin for easy drilling; I punched the holes with a flat-ended metal punch and a hammer. (A piece of steel rod with one end filed flat will do.) Support the brass sheet on a block of scrap wood with the end grain facing upward. Support the wood on a concrete floor or in a sturdy vise. Move to a fresh area of the block to punch each hole.

Dry Attenuator

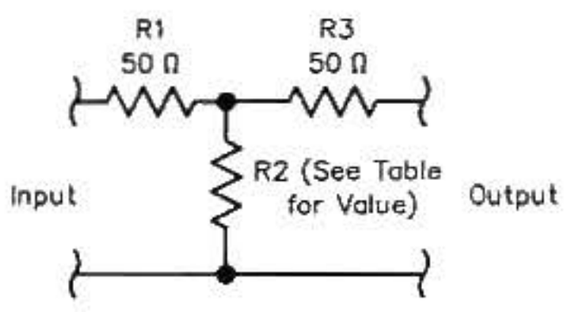
Temporarily unsolder the input connector and remove the resistor and shield. Of the four metal standoffs, discard the fourth one, which grounded the resistor. Carefully drill holes for #4-40 hardware in the top and sides of the resistor shield (Figure 2A). Insert #4-40 screws from inside and fasten small solder lugs to the outside as shown. Bend the lug of Figure 2B as shown and bolt it to the resistor clip where you removed the ground standoff.

Position 12 2-W resistors between the solder lugs and brass plate, 2B. You may need to bend the **U**-shaped tinned wire that holds together the ends of the resistor clip in order to position the top resistors. Bend the wire so as to maintain the clip's compression on the resistor. Test fit everything in the chassis; there should be about 9/16 inch between the brass plate and the inside of the end wall. Solder the resistors in this position.

Mount the output connector at the center of the end wall. It should not extend very far inside the chassis. Solder the four 200-Ω resistors to the brass plate (2B) so as to form a pyramidal shape; the peak will meet the output BNC connector's center terminal.

Table 1
Attenuator Performance

	MFJ-246		*MFJ-250*	
Frequency (MHz)	*Attn (dB)*	*SWR*	*Attn (dB)*	*SWR*
1.8	35.5	<1.04	32.4	1.05
29.9	35.5	<1.04	32.5	1.1
50	35.4	<1.04	32.5	1.14
146	34.7	1.13	32.4	1.25
250	32.4	1.29	30.9	1.25
435	29.2	1.75	30.6	3.57



Component	*MFJ-264 (Dry)*	*MFJ-250 (Oil-Cooled)*
R1	Original dummy load resistor	Original dummy load resistor
R2	12 parallel-connected 20-Ω, 2-W carbon-composite resistors	8 parallel-connected 20-Ω, 2-W carbon-composite resistors
R3	4 parallel-connected 200-Ω, 1/2-W carbon-composite resistors	Second dummy load resistor

Figure 1—Schematic of the **T**-network attenuators.

Mount the circuit in the chassis and solder it to the input and output connectors. Bend the ground strap (Figure 2C) as shown. Support one of the two outside screws on the top of the shield from below with a small screwdriver (or "instant" glue the screw to the shield). Carefully remove the nut, attach the ground strap, and replace the nut. Do the other outside screw similarly. (It helps if the strap is flexible.) Drill holes in the top of the end wall to match the other strap end, and attach it with #4-40 hardware.

Oil-Cooled Attenuator

Procure two MFJ-250s to make one attenuator. Discard the can and lid from the second unit. Punch holes in the first lid for a second SO-239 and mount the second resistor and shield as in Figure 3A.

Bend the two **L** brackets shown in Figure 3B. Drill and screw the brackets to each side of the shields so that the shields are parallel and joined together.

Detach the resistor clips from the shields and rotate them 180°, to position the mounting holes at the open sides of the shields. Bend the **U**-shaped tinned wires that bridge the resistor-clip ends to clear the shields and maintain clip pressure on the resistors.

Solder the #14 AWG (all #14 AWG may be bare or tinned) copper wires to the brass plate of Figure 3C and bend the lugs. Position the eight 2-W resistors between the **L** brackets (inner row of holes) and lugged plate (3C) and bolt the lugs to the resistor clips. There should be a very small gap ($^1/_{32}$ inch or less) between each resistor body and the brass at each end. Solder and trim the resistor leads.

Insert and solder #14 bus wires in the outer row of **L**-bracket holes. Cut the wires to about 1$^1/_2$ inches long on the resistor side. Solder four #14 AWG copper wires across the opening in the remaining plate (Figure 3D). Slide the plate over the bus wires until the gap between the plates (3C and 3D) is about $^1/_8$ inch. Make sure all parts such as wire ends protruding through 3C are at least $^1/_{16}$ inch from 3D. Solder plate 3D to the bus wires and trim the wires short.

Bend the brass shield in Figure 3E to fit over the second aluminum shield (the one at the side of the lid). Bend the lip at the end 90° inward. Put the brass shield in place. It should fit over the **L** brackets near the outside of the can and snugly against the lid (Figure 3A). Make sure that the brass does not touch the resistor-clip screws. There should be a $^1/_8$-inch opening between the brass shield and the back of the aluminum shield near the PL-259. The lip at the end of the brass shield should fit on top of plate 3D. Mark and drill for a sheet-metal screw on each side (Figure 3A). Install those screws. Solder the brass shield to the lid around three sides, to brass plate 3D and to the **L** brackets.

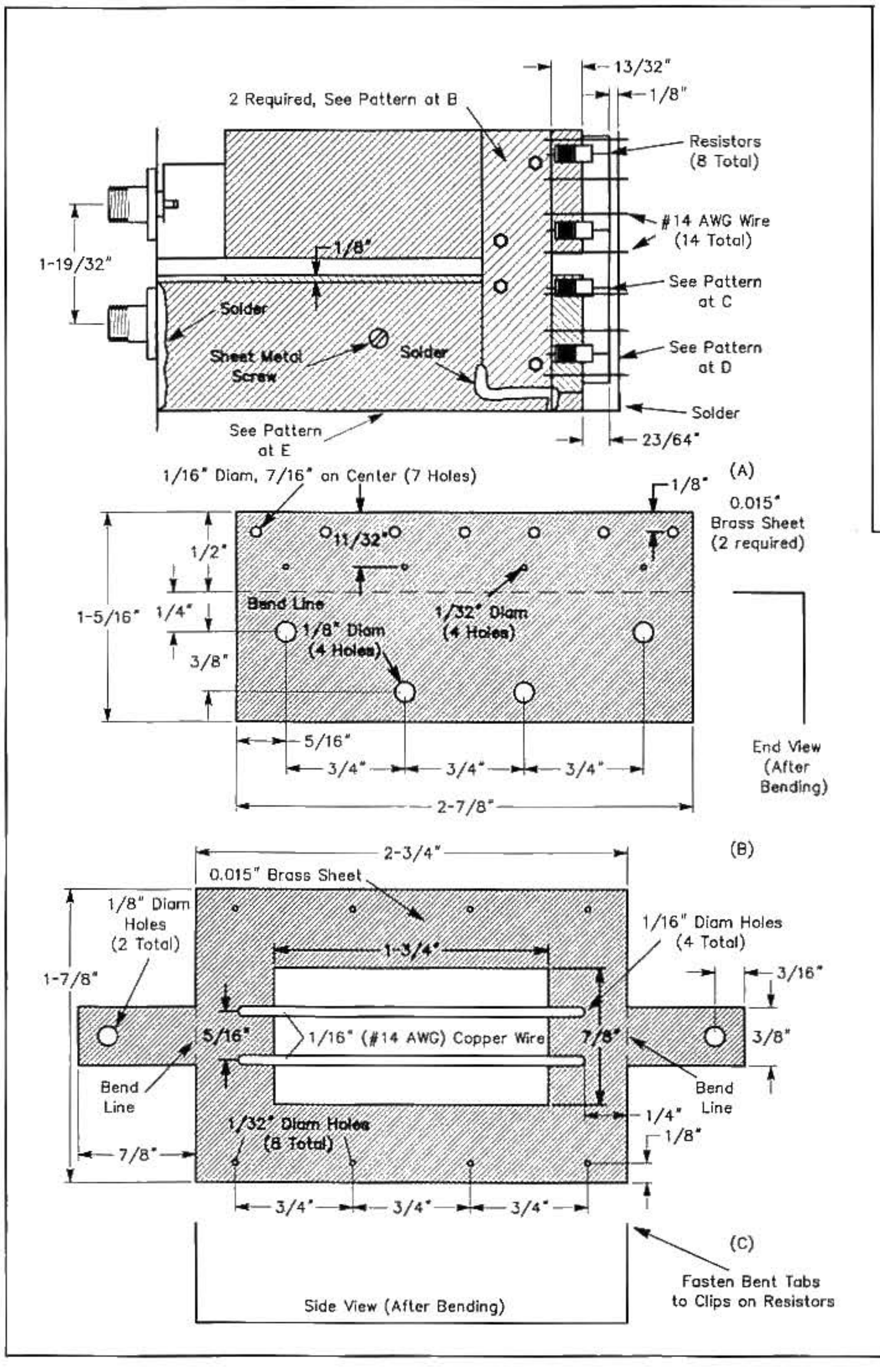
Operation

At 1500 W input, each of the 2-W resistors in the dry attenuator dissipates over 4 W. Nevertheless, the prototype survived a nine-second test at 1500 W (3.5 MHz), which corresponds to the original derating curve. Starting with a cold attenuator, the resistors did not become nearly hot enough to sustain damage. Since the design is asymmetric, *never apply significant power to the output connector*, lest you destroy the output resistors!

The oil-cooled dummy load has an original rating of 1000 W for 10 minutes, when cooled with transformer oil. Oil circulation is critical, and the added components in the attenuator inhibit cooling. Derate the maximum power slightly and reduce the maximum duration for a given power level to 50% of that in the original derating curve, or less. The original SO-239 (in the center of the lid) is the input; the one to the side is the output. The output side will handle hundreds of watts briefly—but not for long!

With a calibrated signal generator (eg, an HP-608) and a spectrum analyzer, you can easily calibrate your attenuator over its full frequency range.

Thirty decibels or more is good for a single-stage attenuator, but most spectrum analyzers need more attenuation for safe operation with high-power transmitters. Additional attenuation stages can be inexpensive, low-power commercial units that are often available as surplus. You may also want to



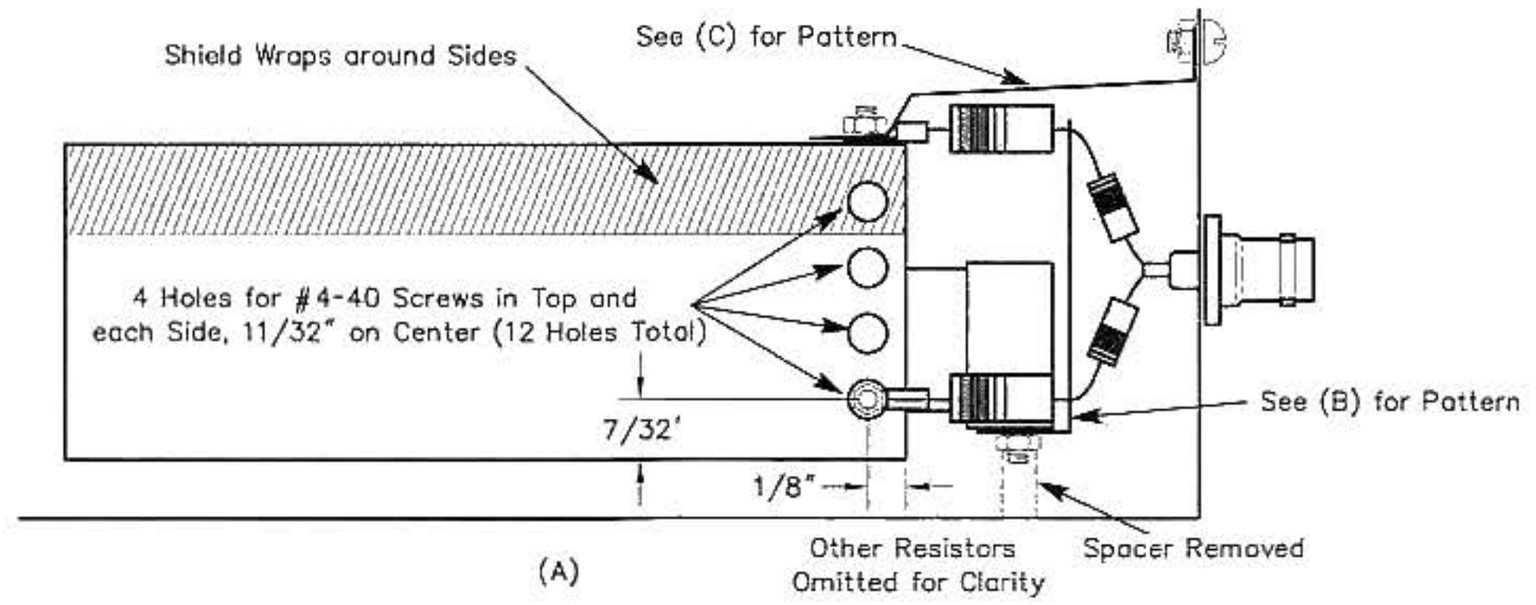


Figure 2—Mechanical details and patterns for the MFJ-264 conversion.

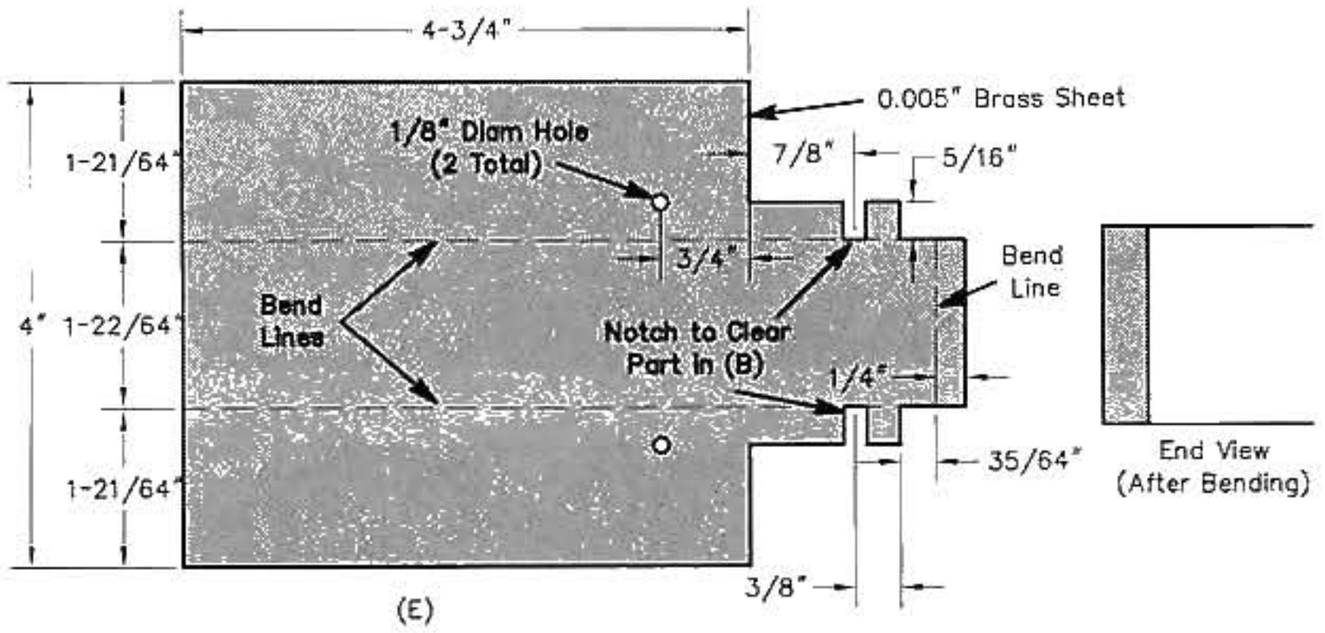


Figure 3—Mechanical details and patterns for the MFJ-250 conversion.

look at the new attenuators available from Pasternack Enterprises.[1]

It's convenient to have your attenuator hooked up as a dummy load for station tune-ups. Any time during tune-up, you can use the attenuator output for signal quality checks. The same output is convenient for driving a transverter. If you were just thinking about getting a dummy load, the attenuator function is almost free!

[1]Pasternack Enterprises, PO Box 16759, Irvine, CA 92713; tel 714-261-1920, fax 714-261-7451.

Erik Basilier was born in Sweden in 1947 and obtained his first amateur license there in 1963. Still licensed in Sweden, he obtained his first US license in 1988. In Sweden, he obtained a Master of Engineering in technical physics and, in 1980, a PhD in experimental physics with a thesis about computerized electron spectroscopy. This work included design and construction of electronics and computer systems, as well as fundamental physics research. Erik is currently employed by Motorola in the Phoenix, Arizona, area, where he does systems programming for Motorola's Semiconductor Products Sector. QST